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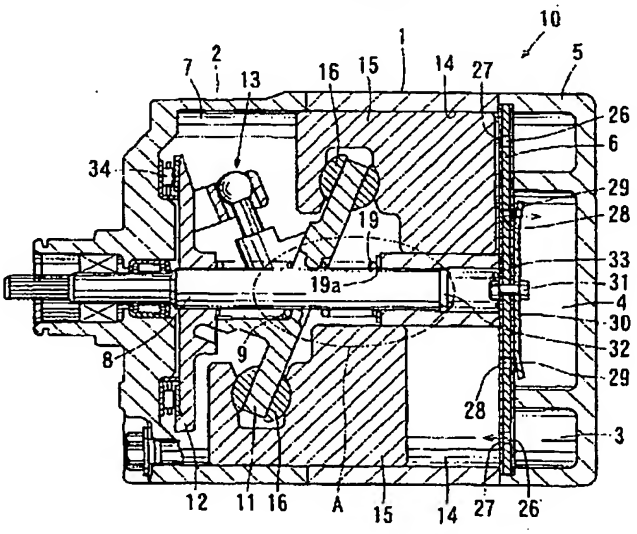
(54) Variable displacement compressors

(57) A variable displacement compressor 10 includes return springs 9 and 19 that press a swash plate 11 in the axial direction of a drive shaft 8. One end of the return spring 19 is fastened to the swash plate 11, and the other end is fastened to a ring-like (toric) receiving plate 19a through which the drive shaft 8 is inserted. When the swash plate 11 rotates, the return spring 19 and the receiving plate 19a rotate in synchronism with the swash plate 11, and the receiving plate 19a slides in contact with a contact portion 1a of the cylinder block 1.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to variable displacement compressors that may preferably be used in automotive air conditioning systems and other devices.

Description of Related Art

[0002] As one type of known compressors, a variable displacement compressor is disclosed in Japanese unexamined patent specification No.2000-2180 and is typically used in automotive air conditioning systems. The variable displacement compressor changes the compressor output discharge capacity by changing the pressure within a crank chamber that includes a swash plate. The swash plate is coupled to a drive shaft and rotates together with the drive shaft. The swash plate changes the inclination angle with respect to the plane perpendicular to the axis of the drive shaft. A return spring is disposed around the circumference of the drive shaft near the swash plate. The return spring urges the swash plate in the axial direction of the drive shaft and holds the swash plate in a set position (e.g., a position slightly inclined relative to the plane perpendicular to the axis of the drive shaft) while the compressor is not operating. The drive shaft includes a ring groove on the axial circumference of the drive shaft. A ring-shaped circular clip (fastener) fastened in the ring groove serves as a receiving portion for receiving the end of the return spring.

[0003] In such compressors, a ring groove must be formed in order to fasten the circular clip to the drive shaft. Moreover, in automated assembly conditions, confirmation process is necessary to determine whether or not the machinery has accurately inserted the circular clip into the ring groove.

SUMMARY OF THE INVENTION

[0004] It is, therefore, an object of the present invention to provide improved variable displacement compressors.

[0005] In one aspect of the present teachings, the variable displacement compressor includes a return spring having a simplified receiving construction.

[0006] In general, the variable displacement compressor includes a drive shaft, a support member, a swash plate, a piston, a return spring, and a receiving portion. The support member supports the drive shaft. The swash plate rotates in synchronism with the drive shaft. The piston is disposed within a cylinder bore. The rotation of the swash plate is converted into the reciprocation of the piston. The stroke length of the piston and the discharge capacity of the compressor changes in accordance with the inclination angle of the swash plate. The return spring is provided on the circumference of the drive shaft between the swash plate and the support member. The return spring urges the swash plate. The receiving portion receives an end of the return spring in contact with a contact portion of the support member between the return spring and the support member. A mechanism for fastening the receiving portion that receives the return spring is therefore not required. As the result, the return spring may have a simplified receiving construction.

[0007] Preferably, the contact portion may be formed on the support member itself. Such a configuration does not require an additional member with a contact portion and allows the contact mechanism of the receiving portion to be simplified.

[0008] In another preferred aspect of the present teachings, the receiving portion may be fastened to the return spring. This allows the return spring and the receiving portion to rotate simultaneously together with the rotation of the swash plate. Localized wearing of the receiving portion by the end of the return spring contacting the receiving portion is thereby prevented.

[0009] In another aspect, the receiving portion may have a ring-like shape. Forming the receiving portion in a ring-like shape corresponding to the exterior shape of the drive shaft allows the receiving portion to be easily attached by inserting the drive shaft in the receiving portion. The pushing action of the return spring allows the receiving portion to secure itself in its designated position.

[0010] The receiving portion may be formed integrally with the contact portion of the support member, which allows for a reduction in the number of parts needed to receive the end of the return spring.

[0011] Preferably, the receiving portion is hardened. If aluminum is utilized to reduce weight, the support member is made of an aluminum alloy. Therefore, when the return spring made of hardened steel is received, the support member may be damaged. However, by hardening the receiving portion, the receiving portion by the end of the return spring contacting the receiving portion is prevented from being worn.

[0012] Additional objects, features and advantages of the present invention will be readily understood after reading the following detailed description together with the accompanying drawings and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Fig. 1 shows a variable displacement compressor according to one of the embodiments.

[0014] Fig. 2 shows an expanded view of the area indicated by broken line A shown in Fig. 1.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Compressors include, for example, a support member that supports a drive shaft.

[0016] A swash plate is provided to rotate in synchronism with the drive shaft and the rotation of the swash plate is converted into reciprocation of a piston within a cylinder bore. The stroke length of the piston and the compressor output discharge capacity of a fluid (refrigerant) change when the inclination angle of the swash plate changes.

[0017] In addition or in the alternative, compressors include a return spring that is provided on the circumference of the drive shaft between the swash plate and the support member. Preferably, the return spring urges or biases the swash plate. In addition or in the alternative, a receiving portion is provided to receive the end of the return spring in contact with a contact portion of the support member between the return spring and the support member.

[0018] In other embodiments, the compressor may include means for receiving the end of the return spring in contact with a contact portion of the support member between the return spring and the support member. In other compressors, the contact portion may be formed on the support member itself. Moreover, the receiving portion may be fastened to the return spring. The receiving portion may optionally have a ring-like shape. Further, the receiving portion is integrally formed with the contact portion. Preferably, the receiving portion has been hardened.

[0019] Methods for manufacturing such compressors are taught. For example, a return spring is provided to urge or bias the swash plate along the axis of the drive shaft and on the circumference of the drive shaft between the swash plate and the support member. In addition, a receiving portion is provided to receive the end of the return spring in contact with a contact portion of the support member between the return spring and the support member.

[0020] Additional examples of the present teachings will be described in greater detail with reference to the attached drawings. This detailed description is merely intended to teach a person of skill in the art further details for practicing preferred aspects of the present teachings and is not intended to limit the scope of the invention. Only the claims define the scope of the claimed invention. Therefore, combinations of features and steps disclosed in the above detail description may not be necessary to practice the invention in the broadest sense, and are instead taught merely to particularly describe some examples of the invention. In addition, the present teachings naturally may be combined in ways that are not specifically enumerated in order to provide additional useful embodiments of the present teachings.

[0021] As detailed examples of the compressors, a variable displacement compressor will now be described with reference to Figs. 1 and 2. In this detailed embodiment, an explanation will be presented of a compressor for an automotive air conditioning system that draws a refrigerant, compresses the refrigerant to a higher pressure, and discharges the high pressure refrigerant. While the present detailed embodiment is taught in terms of a refrigerant, naturally the present compressors are utilized with other fluids.

[0022] As shown in Fig. 1, as one example of the compressor, a variable displacement compressor 10 (hereinafter referred to as "compressor") includes a cylinder block 1, a front housing 2 fixed to the front end (on the left side of the figure) of the cylinder block 1, and a rear housing 5 fixed via a valve plate 6 to the rear end (on the right side of the figure) of the cylinder block 1. The rear housing 5 includes a suction chamber 3 for a refrigerant before compression and a discharge chamber 4 for the compressed refrigerant. Suction valves 27, discharge valves 29, and valve retainers 30 are attached to the valve plate 6 by a fastener 31. The valve plate 6 comprises suction ports 26 that connects the suction chamber 3 and cylinder bores 14 via the respective suction valves 27 and discharge ports 28 that connects the discharge chamber 4 and the cylinder bores 14 via the respective discharge valves 29.

[0023] A drive shaft 8 transmits rotation from a drive source to a swash plate 11 and is inserted through the cylinder block 1 and the front housing 2. The drive shaft 8 is rotatably supported within the cylinder block 1, which functions as a support member. A thrust race 32 and a spring member 33 adapted to urge or bias the rear end of the drive shaft 8 forward (toward the side of the front housing 2) are disposed in the cylinder block 1 on the side of the rear housing 5. The elastic urging force of the spring member 33 is received by a thrust bearing 34 disposed between a rotor 12 and the front housing 2.

[0024] A disk-like swash plate 11 is disposed within a crank chamber 7 defined in the front housing 2. The swash plate 11 is coupled to the drive shaft 8 and rotates together with the drive shaft 8. The swash plate 11 is supported on the drive shaft 8 slidably in the axial direction and inclinably with respect to the drive shaft 8. The rotor 12 is fastened to the drive shaft 8. The rotor 12 rotates integrally with the swash plate 11 via a hinge mechanism 13 to transmit the rotation of the drive shaft 8 to the swash plate 11. The rotor 12 allows the swash plate 11 to rotate at various inclination angles.

[0025] Return springs 9 and 19 apply pressure to the swash plate 11 in the axial direction of the drive shaft 8 and are located on the circumference of the drive shaft 8 near the swash plate 11 (on the left and right sides of Fig. 1). The ends of the return spring 9 are respectively received by the swash plate 11 and the rotor 12. The ends of the return spring 19 are received by the swash plate 11 and a receiving plate 19a. The receiving plate 19a is supported in contact with the cylinder block 1. As a result of the balance between the return springs 9 and 19, the swash plate 11 is held in a designated position (e.g., a position slightly inclined relative to the plane perpendicular to the axis of the drive shaft 8) when the compressor 10 is not operating. The receiving plate 19a functions as a receiving portion or receiving means as

utilized herein.

[0026] A detailed description of the portion of the compressor proximal to the return spring 19 and the receiving plate 19a will be provided with reference to Fig. 2. As shown in Fig. 2, the receiving plate 19a has a ring-like (toric) shape with an insertion hole 19b corresponding to the exterior shape of the drive shaft 8. The receiving plate 19a is therefore attached by inserting the drive shaft 8 into the receiving plate 19a. One end of the return spring 19 is fastened to the swash plate 11 and the other end is fastened to the receiving plate 19a inserted into the drive shaft 8. The receiving plate 19a is urged in the direction away from the swash plate 11 (the direction of arrow 40 in Fig. 2). Therefore, the return spring 19 and the receiving plate 19a rotate in synchronism with the swash plate 11 when the swash plate 11 rotates. In this case, the receiving plate 19a slides in contact with a contact portion 1a of the cylinder block 1 on the opposite side of the swash plate 11 against the return spring 19.

[0027] A plurality of cylinder bores 14 is arranged using any preferred circumferentially spacing around the cylinder block 1. A piston 15 is slidably disposed within each cylinder bore 14. The rear face of each piston 15 is connected to the swash plate 11 via a pair of shoes 16 to convert the rotation of the swash plate 11 into the reciprocating movement of the piston 15. Therefore, when the swash plate 11 rotates together with the rotation of the drive shaft 8, each piston 15 reciprocates within its respective cylinder bore 14 together with the rotational movement. The reciprocating pistons 15 cause, for example, the refrigerant to be drawn from the suction chamber 3 into the cylinder bore 14 (i.e. a suction stroke). Thereafter, a compressed refrigerant is discharged from the cylinder bore 14 to the discharge chamber 4 after compression (i.e. a discharge stroke).

[0028] The output discharge capacity of the compressor 10 is determined according to the stroke length (the distance from the upper dead point to the lower dead point) of the piston 15. The stroke length of the piston 15 is determined by the inclination angle of the swash plate 11 with respect to a plane perpendicular to the axis of the drive shaft 8. More specifically, the stroke length of the pistons 15 and discharge capacity of the compressor 10 increase as the inclination angle of the swash plate 11 increases. On the other hand, the stroke length of the pistons 15 and discharge capacity of the compressor 10 decrease as the inclination angle of the swash plate 11 decreases. The inclination angle of the swash plate 11 during operation of the compressor is determined by the differential pressure between the inside of the cylinder bores 14 and the inside of the crank chamber 7. The differential pressure can be adjusted, for example, by releasing the compressed high-pressure refrigerant into the crank chamber 7 by means of a capacity control valve (not shown).

[0029] In the variable displacement compressor 10, the receiving plate 19a can receive the return spring 19 in contact with the contact portion 1a of the cylinder block 1 that supports the drive shaft 8. Thus, it is not necessary to fasten the receiving plate 19a that receives the return spring 19. For example, it is not necessary to fasten the receiving plate 19a to the drive shaft 8 and processing steps to fasten the drive shaft 8 to the receiving plate 19a can be eliminated. Therefore, the receiving structure of the return spring is simplified by virtue of the receiving plate 19a.

[0030] The contact portion 1a is provided on the cylinder block 1 in order to simplify the contact construction of the receiving plate 19a. Further, the receiving plate 19a is fastened to the return spring 19, so the receiving plate 19a is prevented as much as possible from being locally worn by the end of the return spring 19 when the return spring 19 has rotated. Moreover, the receiving plate 19a is formed as a ring-like (toric) shape corresponding to the exterior shape of the drive shaft 8, so the attachment of the receiving plate 19a is simple.

[0031] Naturally, variety of modifications are made to the above described embodiments without departing from the spirit of the invention. For example, while a ring-shaped (toric) receiving plate 19a that contacts the contact portion 1a of the cylinder block 1 was described above, the receiving plate 19a may have a variety of shapes, sizes, or other features.

In addition, various modifications are possible according to the mutual shapes in an embodiment in which the receiving plate 19a contacts the contact portion 1a of the cylinder block 1. For example, a recess may be formed in the contact portion 1a of the cylinder block 1 so that the receiving plate 19a fits into the recess. In the alternative, a protrusion corresponding to the size of the receiving plate 19a may be formed on the contact portion 1a of the cylinder block 1 so that the receiving plate 19a makes contact with the protrusion. Moreover, the contact portion need not be present on the cylinder block 1 itself, and may instead be present on a separate member attached to the cylinder block 1.

[0032] In the description of the above embodiments, the cylinder block 1 may include a separate receiving plate 19a. However, the location corresponding to receiving plate 19a is also established integrally on the contact portion 1a of the cylinder block 1. At such a time, hardening the location that receives the end of the return spring 19 substantially prevent the wearing of the location corresponding to the receiving plate by the contact portion 1a of the cylinder block 1.

Claims

1. A variable displacement compressor comprising:

   a drive shaft,
   a support member supporting the drive shaft,
   a swash plate that rotates in synchronism with the drive shaft,
   a piston that is disposed within a cylinder bore,

wherein the rotation of the swash plate is converted into the reciprocation of the piston, and the stroke length of the piston and the discharge capacity of the compressor change in accordance with the inclination angle of the swash plate,
a return spring provided on the circumference of the drive shaft between the swash plate and the support member, the return spring urging the swash plate, and
a receiving portion receiving an end of the return spring in contact with a contact portion of the support member between the return spring and the support member.

2. A variable displacement compressor according to claim 1, wherein the receiving portion is fastened to the return spring.

3. A variable displacement compressor according to claims 1 or 2, wherein the receiving portion substantially has a ring shape.

4. A variable displacement compressor according to any one of claims 1 to 3, wherein the receiving portion is integrally formed with the contact portion.

5. A variable displacement compressor according to any one of claims 1 to 4, wherein the receiving portion has been hardened.

6. A variable displacement compressor having a support member that supports a drive shaft, a swash plate that rotates in synchronism with the drive shaft, a piston that is disposed within a cylinder bore, wherein the rotation of the swash plate is converted into the reciprocation of the piston, and the stroke length of the piston and the discharge capacity of the compressor change in accordance with the inclination angle of the swash plate, further comprising:

a return spring provided on the circumference of the drive shaft between the swash plate and the support member, the return spring urging the swash plate, and
means for receiving an end of the return spring in contact with a contact portion of the support member between the return spring and the support member.

7. A variable displacement compressor according to any one of claims 1 to 6, wherein the contact portion is formed on the support member itself.

8. A variable displacement compressor according to claim 6 or 7, wherein the means for receiving the end of the return spring is fastened to the return spring.

9. A variable displacement compressor according to any one of claims 6 to 8, wherein the means for receiving the end of the return spring is formed in a ring-like shape.

10. A variable displacement compressor according to any one of claims 6 to 9, wherein the means for receiving the end of the return spring is integrally formed with the contact portion.

11. A variable displacement compressor according to any one of claims 6 to 10, wherein the means for receiving the end of the return spring has been hardened.

12. A method for manufacturing the variable displacement compressor according to any one of claims 1 to 11 comprising:

providing a return spring urging the swash plate on the circumference of the drive shaft between the swash plate and the support member and providing a receiving portion that receives the end of the return spring in contact with a contact portion of the support member between the return spring and the support member.

13. A method as in claim 12, further comprising forming the contact portion on the support member itself.

14. A method as in claim 12 or 13, further comprising fastening the receiving portion to the return spring.

15. A method as in any one of claims 12 to 14, further comprising forming the receiving portion into a substantially ring shape.

16. A method as in any one of claims 12 to 15, further comprising integrally forming the receiving portion with the contact portion.

17. a method as in any one of claims 12 to 16, further comprising hardening the receiving portion.

FIG. 1

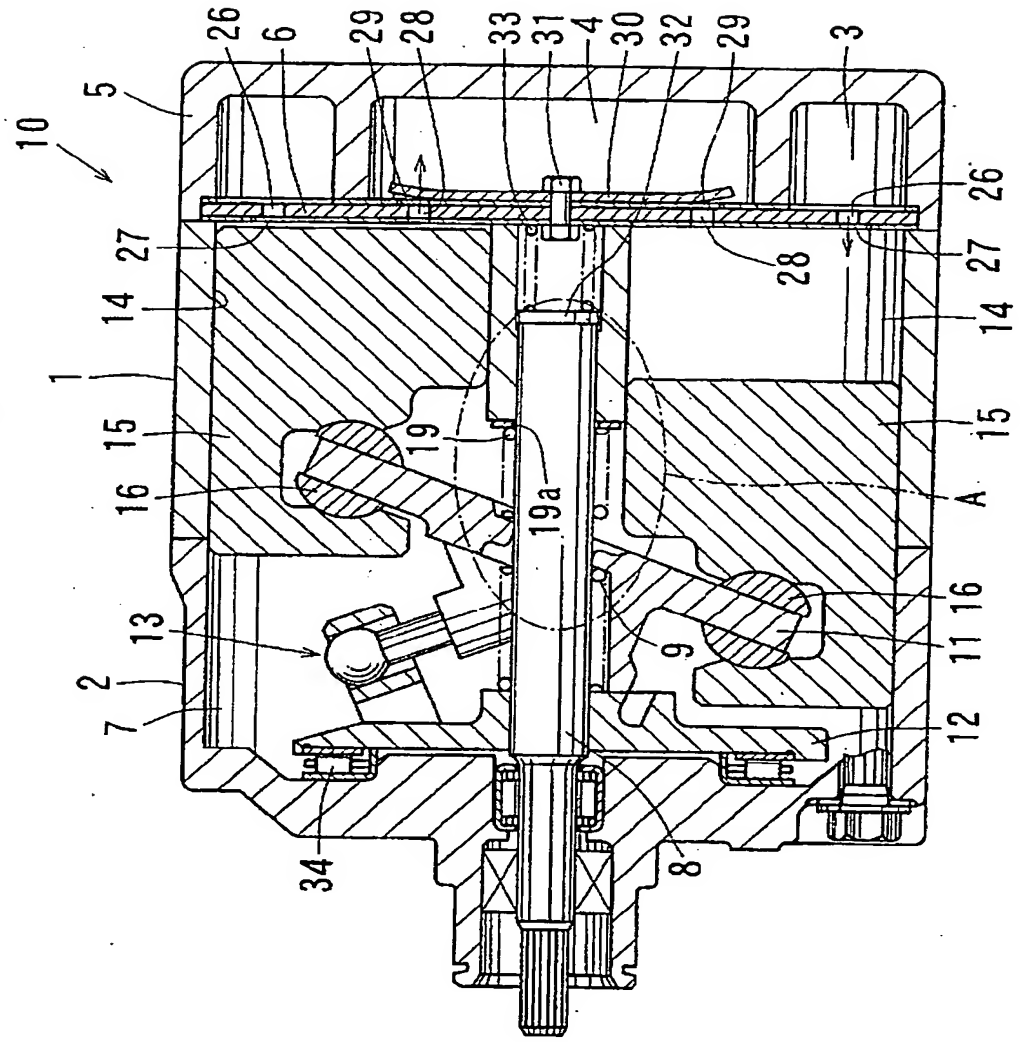
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FIG. 2

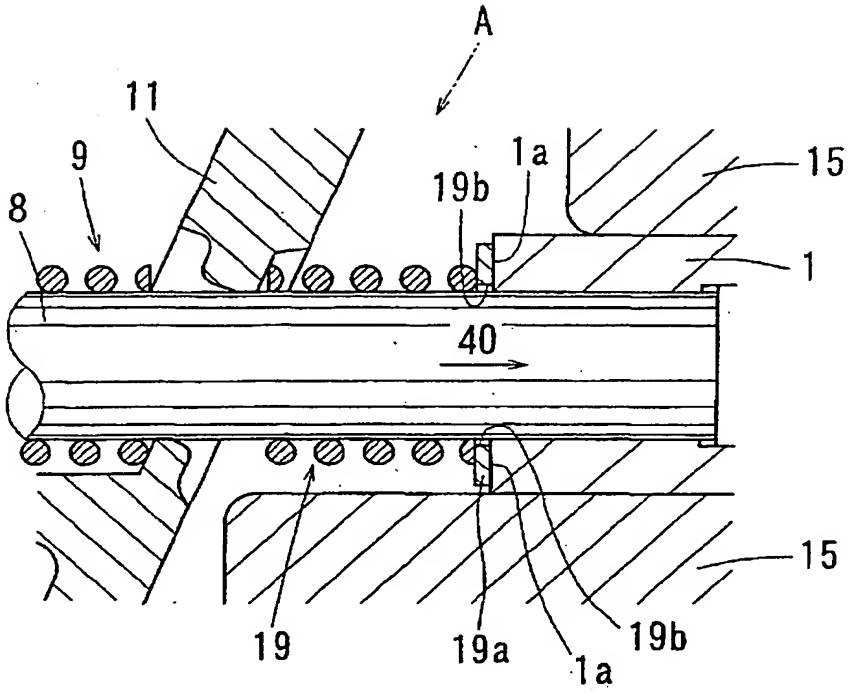

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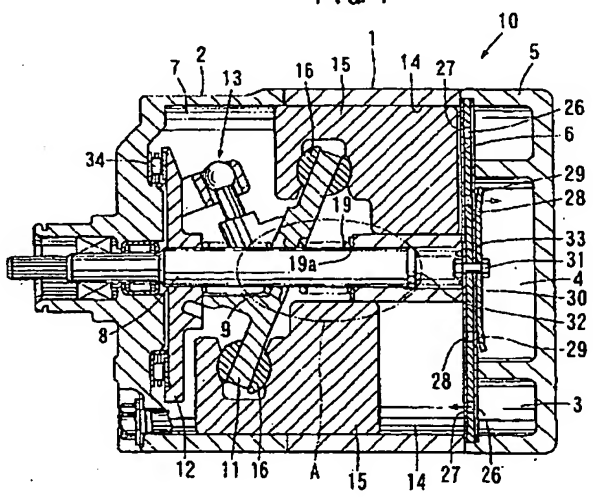
FIG. 1



EP 1 146 228 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 01 10 7888

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Y	* abstract; figures * * column 1, line 25-47 * * column 2, line 15-26 * * column 4, line 53 - column 6, line 27 * * claims * ---	2,8,14	
Y	US 5 894 782 A (NISSEN HARRY STENTOFT ET AL) 20 April 1999 (1999-04-20) * abstract; figures 1,2 * * column 5, line 36-53 * * column 6, line 54 - column 7, line 2 * * claims 4-14 * ---	2,8,14	
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Y	* abstract; figures 2,3 * * column 5, line 1-24 * * claims 1,2 * ---	2,8,14	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	27 November 2003	Richmond, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 573 379 A (KIMURA KAZUYA ET AL) 12 November 1996 (1996-11-12)	1,3-7, 9-13,15, 16	
Y	* abstract; figure 1 * * column 2, line 23-31 * * column 6, line 49-52 *	2,8,14	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 10 7888

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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